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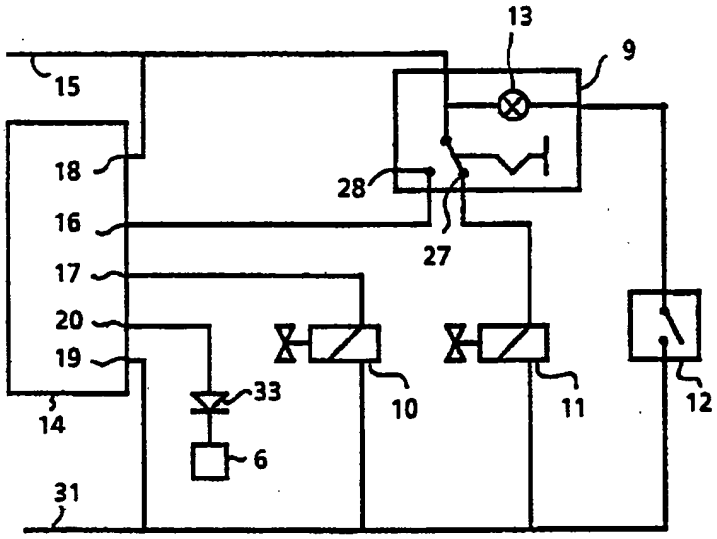

(57) Abstract

An arrangement for engaging a differential lock in a vehicle incorporating a control unit (14) which firstly engages the differential lock via servo mechanisms (10) and secondly reduces the speed of the engine during engagement via an engine control unit (6). The control unit (14) incorporates a time delay circuit which ensures that the differential lock is engaged with a certain time delay after the engine speed has been reduced. The arrangement enables the engagement to take place quickly and automatically without the risk of the driving wheels of the vehicle spinning during engagement.

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Arrangement for controlling the differential lock in a motor vehicle

This invention relates to an arrangement according to the preamble to patent claim 1 attached.

State of the art

In a motor vehicle, particularly in a heavier vehicle such as a truck, it is normal for its transmission to incorporate a differential lock. By activating the differential lock the driving characteristics of the vehicle can be substantially improved, e.g. on a slippery surface. Driving with the differential lock engaged also has disadvantages which curtail the possibilities of controlling the vehicle. For this reason it is preferable not to drive with the differential lock permanently engaged but to be able to engage it when necessary and disengage it in all other types of driving.

The engagement of the differential lock brings about a mechanical, rigid coupling in the differential gear of the vehicle. If the differential gear is engaged whilst one of the wheels of the vehicle is spinning there is a high risk that the differential lock will be damaged because it will then be subjected to excessive stresses.

As a solution to this problem a method is known from SE 404 675 for preventing the engagement of the differential lock until the clutch pedal of the vehicle has been depressed. This gives rise to an interruption in the driving force which prevents a wheel from skidding during engagement of the differential lock. At the same time the transmission is not subjected to driving moments from the engine during engagement.

Under certain driving conditions at least, this solution is in fact one solution to the above-mentioned problem, but it can create other problems instead. The driver has to operate several controls, and the time it takes to carry out these operations can be fairly long, giving the vehicle speed time to drop considerably before the driving force returns. The speed may therefore have time to drop substantially, particularly when driving uphill on a slippery surface, which means that it will also be necessary to select another gear. For

certain vehicle types, at any rate, clutch control can be a relatively cumbersome operation. Moreover, every clutch operation gives rise a certain amount of wear on the clutch.

Object of the invention

The object of this invention is to solve the problem described without entailing the above-mentioned disadvantages. The object of the invention is therefore to ensure that the differential lock can be engaged without the risk of damage to the same by making sure that no driving wheel is spinning during engagement. In cases where a wheel is already spinning, the invention must ensure that this spinning stops before the differential lock is engaged. A further object is to ensure that the differential lock can be engaged easily without the need for several different control movements. Another object is to ensure that the engaging time is reduce, thereby reducing the risk that the speed of the vehicle might be reduced during engagement.

Brief description of the invention

According to the invention this is achieved by designing the arrangement with the special features indicated in the characterising part of patent claim 1 attached. Because the control unit therefore automatically controls both the engagement of the differential lock and the engine acceleration during engagement, both these activities can be optimised relative to each other. The differential lock can be engaged quickly whilst keeping the deceleration time short. The operation will be simple because only a single control need be operated. The engagement can take place without the risk of the driving wheels spinning during engagement, and without the risk of damage to the differential lock.

Further special features and advantages characterising the invention are indicated in the following description exemplifying two embodiments of the invention. The description is given with reference to the attached drawings.

Description of the drawings

Figure 1 shows diagrammatically a vehicle with a differential gear,
Figure 2 is a wiring diagram of an arrangement for controlling a differential lock,
Figure 3 shows an electrical control unit incorporated in the arrangement,
Figure 4 is a signal diagram for the electrical control unit, and
Figure 5 shows a modified embodiment of the invention applied to a tandem driven truck with pneumatic suspension.

Description of an exemplifying embodiment

Figure 1 shows diagrammatically a vehicle 1, such as a truck or other heavier vehicle. At the front end of vehicle 1 is arranged a driving engine 2, which transfers driving force, via a transmission 3, to the rear driving wheels 4 of the vehicle. The acceleration of engine 2 is controlled by the driver by means of a so-called electric accelerator pedal 5, which means that the transmission between the accelerator pedal and the engine takes place electrically instead of mechanically. For this purpose an electrical control unit 6 is connected to the engine and controls the acceleration of engine 2 dependent, among other things, on signals from accelerator pedal 5. Engine control unit 6 is also connected to other transmitters in the vehicle for optimum control of engine 2. Transmission 3 incorporates, conventionally, a differential gear 7 on the drive shafts for driving wheels 4. Differential gear 7 incorporates a differential lock 8, by means of which driving wheels 4 of the vehicle can be mechanically coupled together. Differential lock 8 is controlled by means of pneumatic servomechanisms which are controlled by means of electrical solenoid valves.

Figure 2 is an explanatory wiring diagram of an arrangement for controlling differential lock 8. A manual switch 9, for engaging and disengaging differential lock 8, is arranged near the driver's seat. Near differential gear 7 are arranged two solenoid valves 10, 11, one solenoid valve 10 of which, when activated, supplies compressed air to the servomechanisms of differential lock 8 for engaging differential lock 8, whilst the other solenoid valve 11, when activated, de-aerates the servomechanisms, thereby

disengaging differential lock 8. Near differential lock 8 is arranged a mechanical switch 12, which closes when differential lock 8 is engaged and which opens when it is disengaged. This switch 12 is connected in series to a control lamp 13, which is used to indicate when differential lock 8 is engaged. In this example control lamp 13 is built into control switch 9, as shown in Figure 2.

The arrangement also incorporates an electrical control unit 14, whose function is described in greater detail below with reference to Figures 3 and 4. This control unit 14 is connected via an input 16 to control switch 9, via a first output 17 to solenoid valve 10 for engaging differential lock 8, and via connections 18, 19 to feed cables 15, 31 in the vehicle. One feed cable 15 constitutes a positive feed and the other feed cable 31 constitutes an earth cable. These feed cables 15, 31 are also connected to the other components, as shown in Figure 2. In addition, control unit 14 is connected via a second output 20 to engine control unit 6 via a diode 33 locking against inverse currents.

Figure 3 shows control unit 14 in the form of a functional diagram. The symbols used in Figure 3 for connections 16-20 are the same as those used in Figure 2. Control unit 14 is connected via inputs 18, 19 to feed cables 15, 31 for driving its different sub-components.

Figure 4 illustrates the different signals at input 16 and outputs 17, 20 of the control unit relative to each other along a time axis. When the driver wants to engage differential lock 8, he moves switch 9 to an activated position 28, whereupon a voltage is supplied, via input 16, to an input stage 21 in control unit 14. Curve A in Figure 4 represents the signal at input 16. When switch 9 is in a non-activated position 27, the signal is low, i.e. no voltage is applied to input 16. When the switch is moved to the activated position 28, the signal will be high and it will remain high as long as switch 9 is in this position. Whilst input stage 21 is receiving voltage a circuit 22 is activated which generates a time-limited voltage pulse 23, which is supplied to an output circuit 24. This output circuit 24 is connected via output 20 to engine control unit 6. Curve B in Figure 4 represents the signal at output 20 to engine control unit 6. This signal is low in the non-activated position 27 of switch 9. When switch 9 is moved to its activated positoin 28, the signal at input 16

will become high, whereupon the time- limited pulse 23 will be applied to output 20. During the time this pulse 23 is applied the acceleration of engine 1 will automatically be reduced to idling speed, or to another selected reduced speed, regardless of the action of accelerator pedal 5. Time T which this pulse 23 lasts should be between 0.5 and 2 seconds, preferably approximately 1.0 second, depending on which engine 1 and differential lock 2 is used. Time T of pulse 23 should be chosen so that it is sufficiently long firstly to allow engine 2 time to slow down safely to idling speed, and secondly to allow differential lock 8 time to be engaged. At the same time, time T should not be unnecessarily long since it delays returning to normal acceleration. When this time T has expired the voltage at output 20 ceases to be applied and the acceleration returns to that determined by the position of accelerator pedal 5, or by other engine parameters.

Whilst pulse 23 is generated a time delay commences in a parallel time delay circuit 25, which after a predetermined time t activates a second output circuit. This applies a voltage to the second output 17, which is connected to solenoid valve 10 for engaging differential lock 8. This time delay t should be between 0.1 and 0.5 seconds. In tests times of between 0.2 and 0.4 seconds, and particularly around 0.3-0.4 seconds, have proved suitable. This time t should be chosen so that it is sufficiently long to allow engine 1 time to slow down safely to idling speed for the engagement of differential lock 8, but at the same time no longer than necessary. Curve C in Figure 4 represents the signal at output 17 to the solenoid valve for engaging differential lock 8. During the predetermined time t, after the signal at output 20 has become high, the signal at output 17 will also be high and will remain high as long as the signal at input 16 is high.

Whilst voltage is applied to output 17 differential lock 8 will be engaged. Voltage is then applied to output 17 until the driver disengages differential lock 8 by operating switch 9. When this happens the voltage supply to input 18 is disconnected, and voltage is instead applied directly from switch to solenoid valve 11, which disengages differential lock 8. When differential lock 8 is disengaged neither engine control unit 6 nor the acceleration of engine 1 is affected.

Figure 5 is a modified wiring diagram for using the invention in another vehicle, namely a truck with a pneumatically suspended tandem bogie incorporating two driving rear axles. Each axle incorporates a differential gear and there is also a differential gear which splits the driving force between the two driving axles in the bogie. The vehicle therefore has a total of three differential gears, each of which is provided with a differential lock. To facilitate control of these, however, only two separate switches are used, one of which controls the differential lock between the axles and the other controls together the two differential locks on the respective axles.

In this type of vehicle all four driving wheels in the bogie are normally used to provide a high loading capacity. During driving on a slippery surface and with a light load the contact pressure between the tyre and the road surface may be low, causing the wheels to skid. By de-aerating the air bellows incorporated in the pneumatic suspension for the rear driving axle, this axle is prevented from absorbing any load exceeding its own weight. Instead the load on the front driving axle will increase, hopefully also causing the slipping to stop. Before the rear axle is being de-aerated it is first necessary to engage the differential lock, at least the differential lock located between the axles, but suitably also the other differential locks.

The arrangement shown in Figure 5 for controlling the differential lock for the differential gear between the axles indicates that its right-hand section has the same structure and operation as described above. The only difference is that it is a differential gear between two axles instead of a differential gear on one driving axle. Despite this difference the same reference symbols as used earlier are used for this figure, where possible. To control the differential locks on the respective axles an arrangement can be used such as that described above with reference to Figures 2 and 3.

The air bellows of the rear axle are controlled by means of a manual adjustable switch 30 on the instrument panel of the vehicle. Switch 30 applies voltage, when activated, to a solenoid valve 31, which evacuates the air in the air bellows. At the same time voltage is applied to input 16 on an electronic unit 14 similar to that described earlier. A diode 32 is arranged on a cable between pneumatic suspension switch 30 and input 16 for locking against inverse currents. When the pneumatic suspension switch 30 has been

activated and voltage applied to input 16, engine 1 slows down to the idling speed in similar fashion to that described earlier. After a certain time delay t differential lock 8 is engaged. Thus the engagement can take place without any appreciable driving force being transferred in transmission 6 and without the risk of differential lock 8 being subjected to high stresses.

The invention described in the two examples enables the differential lock to be engaged without the driver having to perform any additional control movements to actuate the acceleration of engine 1. Because the arrangement is therefore independent of the control movements of the driver the differential lock engagement time can be optimised. For example, when a vehicle is being driven on a slippery surface uphill, it is extremely important that the differential lock can be engaged quickly, otherwise there is a risk that the vehicle will come to a complete standstill before the differential lock is fully engaged and the driving force restored.

The invention only involves minor modifications to existing components in a vehicle. Most of the components, for example engine control unit 6 described, are already installed on many modern vehicles. Such engine control units 6 already incorporate inputs which, when voltage is applied to them, reduce the speed of engine 1 to idling speed. This is used, for example, if the vehicle is equipped with an electrical booster brake, a so-called retarder. When this is activated the engine speed is also reduced to idling speed. If there are in this case several connections to engine control unit 6, they should be separated by means of diodes 33, as shown in Figures 2 and 5, to prevent inverse currents.

Electronic unit 14 is described above mainly on the basis of its functional operation because its component parts themselves consist of conventional electronic solutions for forming circuits 22, 23, 24, 26 for pulse generation 22, time delay and driving stage.

According to the exemplified embodiments the signals are transmitted to outputs 17, 20 under full time control, and there is no feedback to indicate that the engine speed is actually being reduced or that differential lock 8 is actually being engaged. This means that the solution will be simple. In more advanced embodiments of the invention it is conceivable to arrange a

feedback to reduce the length os time pulse T and time delay t in order to reduce the time for engagement of differential lock 8. However, in tests carried out the use of the arrangements described, with a simple timed control, has proved satisfactory.

Within the scope of the patent claims attached the invention can be modified and designed differently from the examples given in the description.

PATENT CLAIMS

1. Arrangement for controlling a differential lock incorporated in a vehicle transmission (3) connected to an engine (2), having a switch (9) for initiating engagement of the differential lock (8), and at least one solenoid valve (10) incorporated in a pressure medium operating servo system for engagement of the differential lock (8), *characterised in*
   that an electrical control unit (14) is connected to be activated by the switch (9) and is designed to activate the solenoid valve (10),
   that the control unit (14) is connected to an engine control unit (6) which actuates the acceleration of the engine (2), and
   that the control unit (14) incorporates a time delay circuit (25) which transmits an output signal for activating the solenoid valve (10) for a certain time (t) after an output signal has been transmitted to the engine control unit for reducing the acceleration of the engine.

2. Arrangement according to patent claim 1, *characterised* in that the control unit (14) is designed to transmit a time- limited output signal (23) to the engine control unit (6).

3. Arrangement according to patent claim 1, *characterised* in that the control unit (14) is designed to transmit an output signal (23) to the engine control unit (6) which reduces the speed of the engine (2) to idling speed.

4. Arrangement according to patent claims 1-3, *characterised* in that the differential lock (8) is incorporated in a differential gear (7) between two driving wheels (4) on the same vehicle axle.

5. Arrangement according to patent claims 1-4, *characterised* in that the differential lock is incorporated in a differential gear between two driving vehicle axles in a bogie.

6. Arrangement according to patent claim 5, *characterised* in
that the control unit is connected to a second switch designed to control the de-aeration of a pneumatically suspended driving axle in a tandem bogie, and
that the control unit, when activated by the second switch, is arranged to transmit automatically the same output signals for engaging the differential lock and for reducing the engine speed as in the activation of the first-mentioned switch.

7. Arrangement according to patent claims 1-2, *characterised* in that the control unit (14) is arranged to transmit output signal (23) to the engine control unit (6) for a time (T) of 0.5 to 2.0 seconds, preferably approximately 1.0 second.

8. Arrangement according to patent claims 1-2, *characterised* in that the control unit (14) is arranged to transmit an output signal to the solenoid valve (10) with a time delay (t) of 0.2 to 0.4 seconds, preferably approximately 0.3 seconds after the control unit (14) has begun to transmit an output signal (23) to the engine control unit (6).

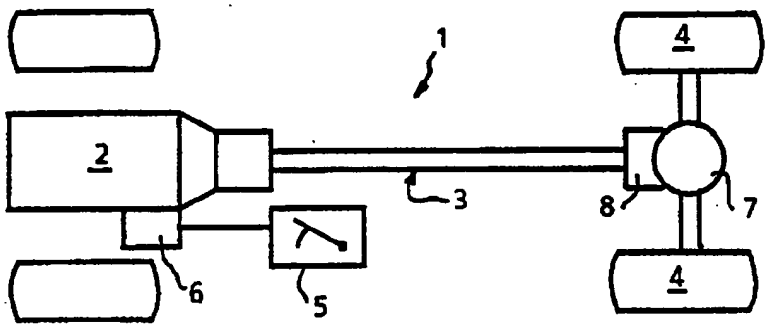
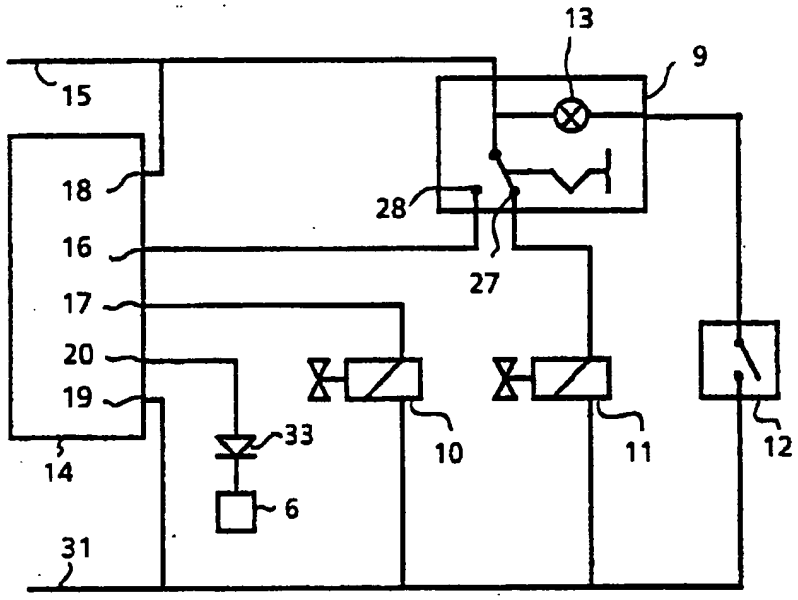


FIG 1

FIG 2



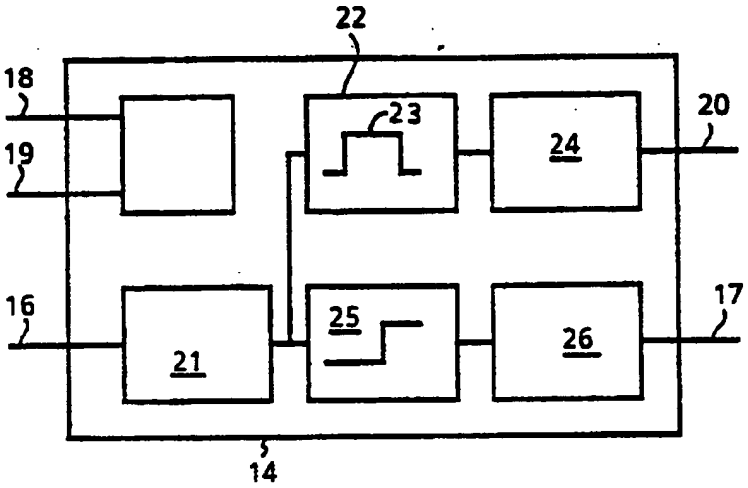


FIG 3

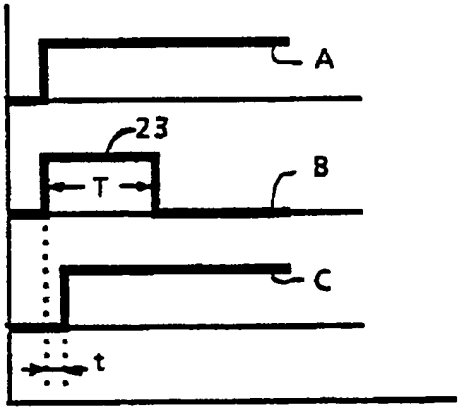


FIG 4

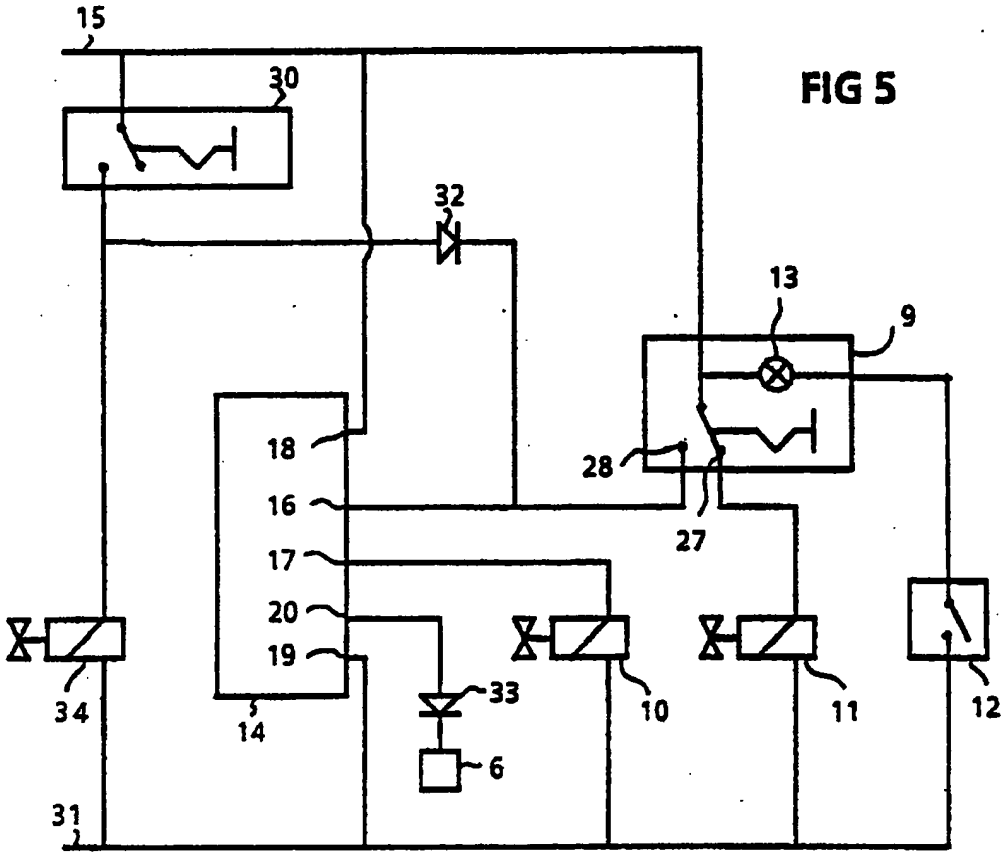


FIG 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 92/00461

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[5]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: B 60 K 23/04, F 16 H 63/40

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	F 16 H; B 60 K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	US, A, 4549448 (KITTLE) 29 October 1985, see the whole document --	
A	US, A, 4523494 (SPARKS ET AL) 18 June 1985, see the whole document --	
A	US, A, 4347760 (JEWETT) 7 September 1982, see the whole document --	
A	SE, B, 404675 (S DÖLERUD ET AL) 23 October 1978, see the whole document --	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
30th September 1992	05 -10- 1992
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	P-O Warnbo

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 92/00461

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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